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Airtanker Cockpit Laser Visibility Evaluation Device
Revision 1

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Background

The Interagency Airtanker Board (IATB) is made up of eight members appointed by the USDA Forest Service (Director of Fire and Aviation Management), the U.S. Department of the Interior (Director of Office of Aircraft Services), and the National Association of State Foresters. The Board charter requires that the Board "accept, review, and evaluate ... airtankers and approve for use ... ." The criteria for this evaluation are contained in a 5100-Fire publication entitled *Interagency Airtanker Board—Charter, Criteria, Forms*, which is available in a three-ring binder (see contact info below). Minimum pilot field of vision and methods of measuring this field are established in the publication.

The visible field for pilots had originally been evaluated in "square inches," an indirect and artificial measure of visibility. This *Tech Tips* replaces square inches with degrees squared, a more logical metric, and lists results obtained on some tankers evaluated to date. [NOTE: Discard any remaining copies of *Equip Tips* 8857 1304, June 1988, "Airtanker Laser Cockpit Visibility Evaluation Device."]

Introduction

The IATB, during the certification of airtankers, evaluates the visibility available to the tanker pilot through the cockpit windows. The evaluation procedure measures angular area of unobstructed view relative to horizontal and vertical reference planes. The horizontal reference plane is parallel to the horizon and passes through a point that is at the normal (mean) height of pilot's eyes above the center of the pilot's seat. The vertical reference plane is parallel to the aircraft's longitudinal axis and passes through the same point. The planes are established with the aircraft in normal flight attitude.

The original method of evaluating visibility was for a "normal" (as close at possible to the 50th percentile height) pilot to sit in the cockpit seat and determine the angles of visibility available using a paper protractor (fig. 1). This "Handy-Dandy Airtanker Visibility Device" was developed by Herb Shields, the aerospace engineer at the San Dimas Technology and Development Center (SDTDC) until his retirement in January 1982. Once the angles were obtained, they were plotted as coordinates on 1/4-inch square graph paper, where 1/4-inch equaled 1 degree. All clear-vision windows were plotted; the obstructions to visibility caused by wings, nacelles, etc. were excluded from the visibility area. (Propeller blades were considered transparent.)

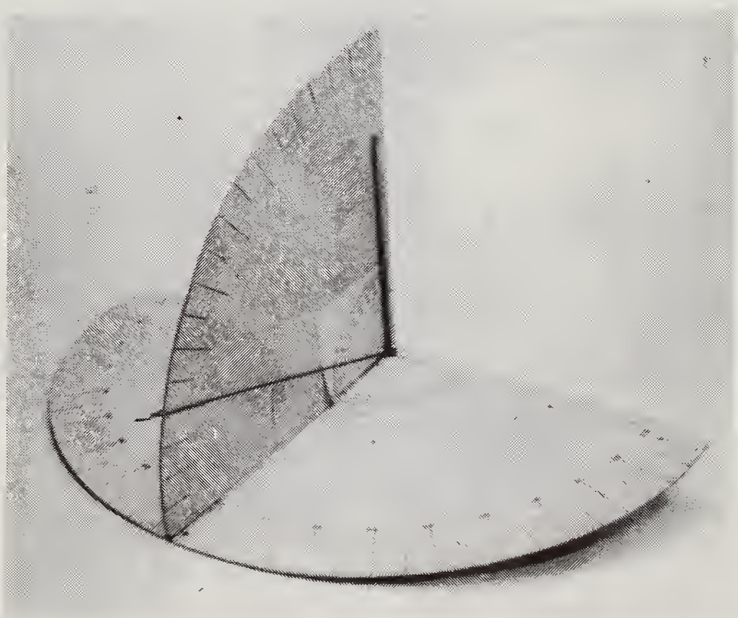

Figure 1. "Handy-dandy" paper protractor airtanker visibility evaluation device.

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The imprecision inherent in this method is obvious. Establishment of a reference point on the horizon, and referral back to the reference point with each angular measurement, made the evaluation a tedious business indeed. Evaluations with the protractor generally took 4 to 5 hours, since repeats were necessary to ensure even ±5 degree accuracy.

The Laser Visibility Evaluation Device

A device to evaluate airtanker pilot's visibility, based on a small laser mounted on the frame of a transit, has been developed and tested by SDTDC. The device (fig. 2) has been found to reproduce measurements within ±1 degree, a substantial improvement over the hand-held method. Evaluations carried out using this device generally take approximately 1 hour, compared to over 4 hours for the handy-dandy paper protractor. Operating instructions for the use of the laser device are set out at the end of this *Tech Tips*. The device, based on a surveyor's transit, uses a low-powered, helium-neon laser to delineate the unobstructed visibility angles for each window. The angles are read directly from the horizontal and vertical scales of the transit.

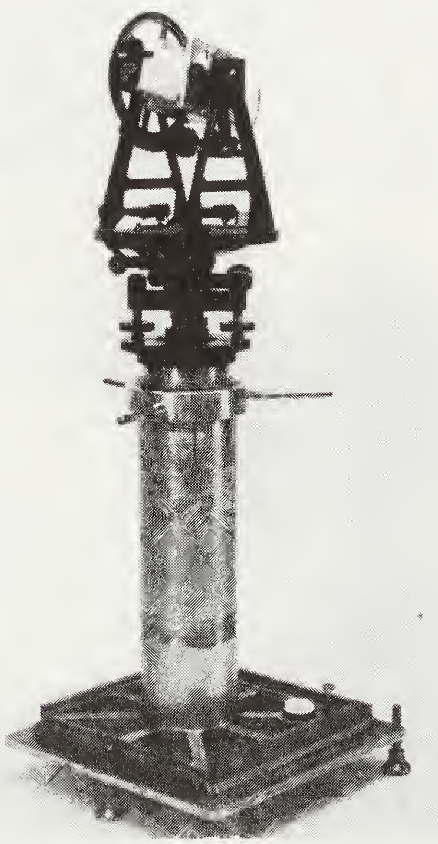


Figure 2. Compact laser, mounted on transit frame, determines airtanker visibility area.

Airtankers Evaluated Using the Laser Device

DC-6 tanker No. 20, owned by Mac Avia International Corp., Santa Rosa, CA, was evaluated in September 1987 at Chico, CA. The DC-6 has been established as the baseline, at 244 square inches, measured with the paper protractor. Using the laser, an area of 304.6 square inches was obtained. This evaluation took approximately 50 minutes, including entering the cockpit, sketching the visibility areas, setting up the instruments, making the evaluation, and disassembling and packing the instrument and leaving the cockpit.

Each angle in the DC-6 was measured at least two times; some were measured three times. In no cases were differences in measurements of the same angle greater than ±2 degrees; in most cases no more than a 1 degree error was seen. Therefore, it is safe to conclude the laser visibility evaluator is accurate within ±1 degree. To ensure continuity of results between those obtained using the protractor and those obtained by the laser, laser evaluations were adjusted by multiplying the laser area by the factor of 244 divided by 304.6 (or 0.801)—the two values being, respectively, the area obtained with the protractor and that obtained using the laser.

A P2V (Navy No. 145903) was also evaluated. The cockpit window situation of the P2V is much more complicated than that of the DC-6. There are eight windows, not just six; also the windows are of a much more complex shape. The DC-6 was evaluated by making 26 separate angular measurements; it took 44 to characterize the P2V. By the time the P2V evaluation was started, the outside air temperature at Chico had reached 110° F and, within the cockpit, temperatures of nearly 140° F were recorded. Even given the difficulty of the measurements and the adverse conditions, the evaluation was completed in 75 minutes.

Since these initial tests, several more tankers have been evaluated using the laser. Results of these tests are shown in table 1. In each case, the evaluation proved to be easy and accurate. The laser has also been used to evaluate the prototype AT-802 tanker. As a result the manufacturer revised the cockpit to improve visibility.

Aircraft	Protractor method (sq in)	Laser method (sq in)	Laser method (sq deg)
DC-4, -6, -7	244	304.6	4,874
PB4Y2	413	515	8,240
P2V; SP2H	1,141	1,425	22,800
C-130	440	550	8,802
KC-97	617	771	12,336
AT802	338	423	6,760

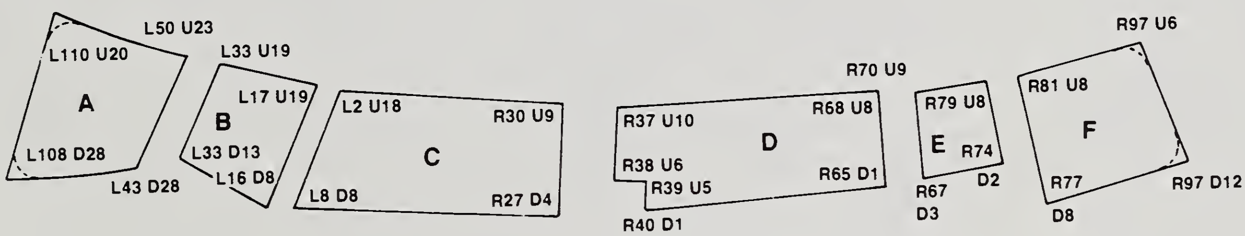
Table 1. Visual field of several aircraft by three methods

The laser visibility device has proven itself a versatile, accurate, and easy to use instrument. Its use should continue. However, the description of the field of unobstructed vision in square inches tends to be confusing. Also, the criteria for visible field have evolved since the laser device was introduced in 1987. Thus, we felt it important to revise the operating instructions.

Operating Instructions for the Laser Visibility Device

1. Make sure that everything you need is on hand. In addition to the laser device itself, an evaluator needs a pad of paper suitable for posting data and a clipboard, a small plumb-bob made-up of a few feet of string with a small weight tied at one end, a tape measure, and a roll of masking tape. A 110-volt ac source should be provided for the laser—either through extension cords or a portable generator. (Although a battery pack is supplied with the device, field experience with the batteries has shown ac power to be more reliable.) If ac power is not available, make sure that you have an adequate supply of batteries, at least two sets of spares.

2. Ensure that the aircraft is approximately in normal flight attitude. This might not be possible in the case of conventional-gear aircraft. Sit in the pilot's seat, adjust the seat fore and aft to a position of comfort, and make a sketch of the outline of each of the aircraft's windows. An example is shown in figure 3.



Notes

1. L = Left
   R = Right
   D = Down
   U = Up
2. Numbers represent degrees
3. All measurements to prolongation lines of straight sides.
   Corner radius side windows approx. 3 in. less

Figure 3. Plot of clear visibility area of a DC-6, with obtained coordinates indicated.

3. Using the small plumb-bob, tape measure, and masking tape, hang the plumb-bob 31.5 inches above the normal position of the seat cushion, and as near as possible in the position a 50-percentile-height pilot's head would be during flight.

4. Remove the aircraft seat cushion or the entire seat if necessary. Install the base of the laser stand; level the base using the bulls-eye level. NOTE: This assumes that the aircraft is in normal flight attitude. If this is not the case (as in conventional-gear aircraft), level the base laterally and ensure that the column of the base is perpendicular to the horizontal plane with the aircraft in level flight. This can be done using a bubble protractor, or can be estimated.

5. Attach the laser head to the base. Using the two levels and four adjusting screws on the laser head, level the laser head, if the aircraft is in normal flight attitude. (Or level it laterally and ensure that the vertical axis of the laser head is parallel to the column of the base if the aircraft is not in level flight attitude.)

6. Position the center of the laser head at the point defined in step No. 3, above, using the small plumb-bob.

7. Set the vertical and horizontal protractors to zero. Turn on the laser. Mark the origin by placing a small piece of masking tape under the laser spot and marking it with a pencil. This will be used to monitor instrument movement throughout the test. Shine the laser spot on the corner of each of the windows. In the event that there is a fillet in the corner, use the prolongation or tangent of each of the straight edges of the window. Record each angle measured on your sketch. Also record the tangent points, and centers of the fillets. It has been found that *the most effective order of recording the angles* is to start near the center of the pilot's field of vision and work to the left extreme, returning to the center and working to the right extreme, and finally returning to the references again for a check to ensure that the laser head has not shifted.

8. Angular measurements can be plotted using any appropriate scale to represent degrees and the total unobstructed visibility area can be calculated in units of square degrees. Don't forget to subtract out wing, nacelle, fillet, etc. obstructions. The result is the tanker's "visibility area." This area, in square degrees, is a revision from previous methods and should be used in future measurements. The new method does not use the 0.801 factor. The data obtained from the laser measurements are particularly suitable for use with "Autosketch" in a personal computer. When using Autosketch, have 1 unit = 1 deg (use the polyline drawing command), and have all left and down angles as negative. Use the area measurement function and Autosketch will calculate the visibility area with a few clicks of the mouse. Obstructions such as wings, nacelles, etc. can be included in the plot and shown as cross-hatched areas. This is how these calculations are made at SDTDC.